APPENDIX G: FLOOD STUDY

A. General. When required, three copies of the completed floodplain analysis study report and the model's digital files shall be submitted. The report submittal must be stamped by a licensed professional civil engineer and include the following information:

1. Floodplain Map.

a. A scaled survey base map stamped by a licensed professional land surveyor in the State of Montana. The map must accurately locate the proposed development with respect to the floodplain, the channel of the subject stream/river, and the existing improvements within the subject study area.

b. The map must show elevation contours at a minimum of 1-foot vertical intervals and shall comply with survey and map guidelines published in the FEMA publication *Guidelines and Specifications for Study Contractors*. The map must show the following:

i. Elevations and ground contours, spot elevations and vertical datum NAVD 88 or NGVD 29 (or most recent vertical datum accepted by Gallatin County).
ii. Elevations and dimensions of existing structures or fill.
iii. Location of proposed lot lines.
iv. Location and elevation of roadways, drainage facilities, bridges, and utility lines.
v. The base maps must be accompanied by all field survey notes/computations, drawings, etc. for each cross-section with water surface elevation at the time the cross section field survey was done.

2. Study Report.

a. Soil maps, groundcover maps and photographs.

b. A narrative report containing purpose of the study and description of the study area, data collection, methodology for both the hydrology and hydraulics, detailed discussion on the input parameters used, modeling results, and conclusions.

c. A floodplain analysis must include calculations and computer analysis input and output information, supporting graphical illustrations, as well as the following information.

i. Scaled cross-sections showing the current/existing conditions of the river/stream channel, the floodplain adjoining both sides of the channel, the cross-sectional area to be occupied by any proposed development and all historic high water information.

ii. Profiles showing the bottom of the channel, the top of both left and right banks and computed base flood water surface elevations for the 10, 25, 50, 100 and 500-year events.

iii. Complete printout of input and output data of the model that was used for the analysis. Liberal use of comments and written discussion will assist considerably in understanding the model logic and minimize misinterpretations and/or questions.

iv. A map showing the graphical/plotted location and limits of the computed floodplain.

v. Three copies of ready to run digital files of both the hydrologic and hydraulic model and its input and output files used in the study. Data shall be submitted on a disk in standard ASCII format, ready to use on an IBM-compatible personal computer and in the applicable software application (e.g. HEC-RAS, etc.)

vi. A section on the flood flow including computer modeling and/or calculations (see below for additional information on flood flow determinations).

vii. Aerial photographs of the site, including during flood events with the specific date and time the photograph was taken.

viii. All field survey notes/computations, maps, and drawings for each cross section with water surface elevation at the time of the cross section field survey.

3. Computer Modeling Information. Floodplain studies submitted to Gallatin County for review must include output summary tables and include the following (but not limited to) items:

a. Cross-section identification number.

b. Range of flows being examined.

c. Computed water surface elevation at each cross-section.

d. Energy grade line at each cross-section.

e. Graphical plots of the channel cross-sections with computed water surface elevations for all model runs including calibrated model runs.

f. All model input and output printouts.

g. Discussion on the starting water surface elevation for the hydraulic model.

B. Determining Flood Flows. The techniques used to determine the flows used in a flood study depend upon whether gage data is available or a detailed flood study has been done and approved for use in Gallatin County. The first technique is used if a gaging station exists on the stream. The second technique is used on un-gaged catchments or those with an insufficient length of record. In all cases, the engineer shall be responsible for assuring that the hydrologic methods used are technically reasonable, conservative, conform to the FEMA publication *Guidelines and Specifications for Study Contractors*, and are acceptable by FEMA and Gallatin County.

1. Flood Flows from Stream Gage Data. Determining flood flows from stream gage data uses the Log-Pearson Type III distribution method as described in the *Guidelines for Determining Flood Flow Frequency, Bulletin 17B of the Hydrology Committee, United States Water Resources Council (revised September 1981).*

a. This technique may be used only if data from a gaging station in the basin is available for a period of at least 10 years.

b. If the difference in the drainage area at the study site and the drainage area at a gaging station in the basin is more than 50%, a continuous model shall be used as described below to determine the flood flows at the study site.

c. In all cases where dams or reservoirs, floodplain development, or land use upstream may have altered the storage capacity or runoff characteristics of the basin so as to affect the validity of this technique, a continuous model shall be used to determine flood flows at the study site.

d. Alternative methodologies may be utilized if industry standard techniques are proposed and approved by County.

2. Flood Flows in Ungaged Basins. Flood flows may be determined by utilizing a continuous flow simulation model such as HSPF or other equivalent continuous flow simulation model, as approved by the County. Where flood elevation or stream gaging data are available, the model shall

be calibrated to the known data. Otherwise, regional parameters may be used.

C. Determining Flood Elevations and Profiles.

1. **Reconnaissance**. The applicant's project engineer is responsible for the collection of all existing data with regard to flooding in the study area. This shall include a literature search of all published reports in the study area and adjacent communities and an information search to obtain all unpublished information on flooding in the immediate and adjacent areas from Federal, State and local units of government. This search shall include specific information on past flooding in the area, drainage structures such as bridges and culverts that affect flooding in the area, available topographic maps, available community maps, photographs of past flood events, and general flooding problems within the community. Documented discussions with nearby property owners should also be done to a obtain witness account of the flooding extent. A field reconnaissance shall be made by the applicant's project engineer to determine the hydraulic conditions of the study area, including type and number of structures, locations of cross-sections, and other parameters including the roughness values necessary for the hydraulic analysis.

2. **Base data**. Channel cross-sections used in the hydraulic analysis shall be current/existing at the time the study is performed and shall be obtained by field survey. Topographic information obtained from aerial photographs/mapping may be used in combination with surveyed channel cross sections in the hydraulic analysis. The elevation datum of all information used in the hydraulic analysis shall be verified. All information shall be referenced directly to NAVD 1988 or NGVD 1929 unless otherwise approved by Gallatin County.

3. **Methodology**. Flood studies shall be calculated using the U.S. Army Corps of Engineers HEC-RAS computer model (or subsequent revision) unless otherwise approved by County.

4. **Adequacy of Hydraulic Model**. Gallatin County considers the following (but not limited to) factors when determining the adequacy of the hydraulic model for use in the floodplain model:

a. Cross-section downstream starting location and spacing.

b. Differences in energy grade line (significant differences in the energy grade line from cross-section to cross-section are an indication that cross-sections should be more closely spaced or that other inaccuracies exist in the hydraulic model.)

c. Methods and results for analyzing the hydraulics of the structures such as bridges and culverts.

d. Lack of flow continuity.

e. Use of a gradually varied flow model. In certain cases, rapidly varied flow techniques may need to be used in combination with a gradually varied flow model such as weir flow over a levee, flow through a spillway of a dam, or special application of bridge flow (pressure flow if bridge superstructure is shown to be submerged for the study event).

f. Mannings "n" value.

g. Calibration of hydraulic model to known and/or observed flow stage elevations including past flood events.

h. Special applications. In some cases, steady state one-dimensional hydraulic models may not be sufficient for preparing the floodplain analysis. This may occur where sediment transport, two-dimensional flow, or other unique hydraulic circumstances affect the accuracy of the model. In these cases, the project engineer musts propose and obtain Gallatin County approval of alternative models for establishing the water surface elevations.

i. All reported error and/or warning messages by the model must be properly and adequately addressed and/or resolved and included in the report for review verification.

THIS PAGE INTENTIONALLY LEFT BLANK